NASA/TM—2000–209891, Vol. 246

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ll and Sara K. Conrad, Editors

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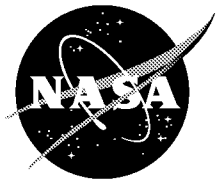
NASA/TM—2000–209891, Vol. 246



Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Sara K. Conrad, Editors

Volume 246

BOREAS TGB-12 ^{222}Rn Flux Data over the NSA

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Eric Sundquist and Greg Winston, U.S. Geological Survey, Woods Hole, Massachusetts

National Aeronautics and
Space Administration

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November 2000

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BOREAS TGB-12 ^{222}Rn Flux Data over the NSA

Susan Trumbore , Eric Sundquist, Greg Winston

Summary

The BOREAS TGB-12 team made measurements of soil carbon inventories, carbon concentration in soil gases, and rates of soil respiration at several sites to estimate the rates of carbon accumulation and turnover in each of the major vegetation types. Sampling strategies for soils were designed to take advantage of local fire chronosequences, so that the accumulation of carbon in new moss growth could be determined. All the data are used to 1) calculate the inventory of carbon and nitrogen in moss and mineral soil layers at NSA sites, 2) determine the rates of input and turnover (using both accumulation since the last stand-killing fire and radiocarbon data), and 3) link changes in soil respiration rate to shifts in the ^{14}C content of soil CO_2 to determine the average 'age' respired CO_2. These ^{222}Rn flux data were collected from 15-Nov-1993 to 16-Aug-1994 over the NSA sites. The data in this data set are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TGB-12 ^{222}Rn Flux Data over the NSA

1.2 Data Set Introduction

This data set contains fluxes of ^{222}Rn emitted from soils. Radon is a noble gas produced from the radioactive decay of 226Ra, which is present in the Lake Aggasiz sediments underlying the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) soils. Radon is itself radioactive, with a half-life of 3.8 days. It is used as a tracer of soil-atmosphere gas exchange. The data presented represent sampling from the fall of 1993 to the summer of 1994.

1.3 Objective/Purpose

The objective of these data is to estimate rates of carbon input, turnover, and accumulation in the soils of each of the major vegetation types at the BOREAS study sites. In addition, the data will be used to relate the estimates of soil carbon dynamics to ecosystem models of the carbon cycle, other measures of carbon cycling dynamics, regional models of soil carbon accumulation, and spatial and temporal models of soil moisture and drainage.

1.4 Summary of Parameters

^{222}Rn flux and soil depth were measured over the BOREAS NSA.

1.5 Discussion

Radon flux data, together with the concentration profile of radon in soil air, may be used to estimate effective diffusivity of gases in soil air, or to test models that predict effective diffusivity based on data such as air-filled porosity. See Davidson and Trumbore (1995) as an example, and for more detail about methods and sampling approaches used here.

1.6 Related Data Sets

BOREAS TGB-12 222Rn Activity Data over the NSA
BOREAS TGB-12 Isotopic Carbon Dioxide Data over the NSA
BOREAS TGB-05 Fire History of Manitoba 1980 to 1991 in Raster Format
BOREAS TE-18 Landsat TM Physical Classification Image of the NSA
BOREAS AFM-12 1-km AVHRR Seasonal Land Cover Classification
BOREAS Regional Soils Data in Raster Format and AEAC Projection
BOREAS Soils Data over the SSA in Raster Format and AEAC Projection
BOREAS TGB-01 Soil CH4 and CO2 Profile Data over the NSA

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Input, Accumulation and Turnover of Carbon in BOREAS NSA Soils (TGB-12)

2.3 Contact Information

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3. Theory of Measurements

A static chamber method was used to determine radon fluxes. Chambers are described in Winston et al. (1997) and problems with chamber sampling in Stephens and Sundquist (1998). After chamber emplacement, samples of chamber air were taken at intervals of 30 to 45 minutes and used to fill pre-evacuated Lucas counting cells. The flux is determined from the slope of radon activity versus time. Special pits were instrumented with thermistors (for monitoring soil temperature), Time Domain Reflectometry (TDR) probes (for monitoring soil water content), and soil gas probes (1/8" stainless steel tubing, perforated at one end and inserted 50 to 100 cm laterally into the soil pit wall, capped with 1/8" swagelock union fittings sealed with a septum). Further details are given in Winston et al. (1997) and in Section 4, below.

^{222}Rn gas samples were obtained using gas-tight syringes (60 cc), dried (by passing through drierite), and then allowed to fill an evacuated Lucas counting cell coated with phosphor scintillant and decay counted. A description of radon sampling and analysis procedures is given in Davidson and Trumbore (1995).

4. Equipment

4.1 Sensor/Instrument Description

Because all of the equipment used in this project is common to many other projects and no special procedures were used, description detail has been minimized in this section, and the reader is referred to the appropriate publications.

- Davidson and Trumbore, 1995
- Mathieu et al., 1988
- Stephens and Sundquist, 1998
- Winston et al., 1997

Radon measurements were made using Pylon alpha scintillation counters.

4.1.1 Collection Environment

Samples were collected under all environmental conditions. Most measurements represent winter conditions.

4.1.2 Source/Platform

Soil.

4.1.3 Source/Platform Mission Objectives

The objective was to determine the soil ^{222}Rn flux.

4.1.4 Key Variables

The key variables measured were ^{222}Rn activity and soil depth. The ^{222}Rn flux was calculated from the collected ^{222}Rn values.

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument

None given.

4.2 Calibration

None given.

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

None given.

4.2.3 Other Calibration Information

Radon cell efficiencies were determined in the lab using background air and 226Ra of known activity absorbed to manganese fibers and sealed in a tube. Counting cell backgrounds were determined using ambient air (see Davidson and Trumbore, 1995, and Mathieu, 1988, for details of radon measurement methods).

5. Data Acquisition Methods

None given.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The North American Datum of 1983 (NAD83) coordinates of the sites were:

```
NSA Old Black Spruce (OBS):          55.88007N, 98.48139W
NSA Old Jack Pine    (OJP):          55.92842N, 98.62396W
NSA Young Jack Pine  (YJP):          55.89575N, 98.28706 W
NSA Gillam Road:                     55.9055 N, 97.70872W
```

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The data are point source measurements made at the given locations.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Soil gas flux and concentration measurements were made from November 1993 to August 1994.

7.2.2 Temporal Coverage Map

Not applicable.

7.2.3 Temporal Resolution

The temporal resolution of the measurements was variable. Some sites were visited once, and others were visited multiple times.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
MEAN_RADON222_FLUX
SDEV_RADON222_FLUX
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
MEAN_RADON222_FLUX	The mean RADON-222 flux measured in the winter 1993-1994 and summer 1994.
SDEV_RADON222_FLUX	Standard deviation for the measured RADON flux determined using a 95% confidence interval.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
MEAN_RADON222_FLUX	[becquerel][meter^-2][minute^-1]
SDEV_RADON222_FLUX	[becquerel][meter^-2][minute^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
DATE_OBS	Investigator
MEAN_RADON222_FLUX	Pylon alpha scintillation counters
SDEV_RADON222_FLUX	Pylon alpha scintillation counters
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-999-GMR02	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	TGB12-RDN01	TGB12-RDN01	None	None	None	None
DATE_OBS	15-NOV-93	16-AUG-94	None	None	None	None
MEAN_RADON222_FLUX	0	2.92	None	None	None	None
SDEV_RADON222_FLUX	.01	.39	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	21-AUG-96	21-AUG-96	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.
Data Not Cllctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A -- Indicates that the value is not applicable to the respective column.
None -- Indicates that no values of that sort were found in the column.

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,MEAN_RADON222_FLUX,SDEV_RADON222_FLUX,CRTFCN_CODE,
REVISION_DATE
'NSA-OJP-FLXTR','TGB12-RDN01',15-NOV-93,.41,.39,'CPI',21-AUG-96
'NSA-999-GMR02','TGB12-RDN01',16-NOV-93,1.65,.3,'CPI',21-AUG-96
'NSA-YJP-FLXTR','TGB12-RDN01',18-NOV-93,.08,.05,'CPI',21-AUG-96
'NSA-OBS-FLXTR','TGB12-RDN01',20-NOV-93,1.8,.26,'CPI',21-AUG-96
'NSA-999-GMR02','TGB12-RDN01',22-NOV-93,.29,.21,'CPI',21-AUG-96
'NSA-OBS-FLXTR','TGB12-RDN01',23-JAN-94,.44,.13,'CPI',21-AUG-96
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data is the ^{222}Rn flux data for a given site on a given day.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

Methods for calculating radon activities and using them for estimating soil gas diffusivity are given in Davidson and Trumbore (1995) and Trumbore (1995).

9.2 Data Processing Sequence

None given.

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

None given.

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables
None given.

9.4 Graphs and Plots
None given.

10. Errors

10.1 Sources of Error
Sources of error include inaccuracies in soil collection and instrument errors during running of samples.

10.2 Quality Assessment

10.2.1 Data Validation by Source
There are many sources of error in flux measurements. The ones associated with the methods used here are detailed in Stephens and Sundquist (1998). Errors involved in soil gas sampling include the possibility that the volume of soil air space sampled (500 cc to 1 liter) represents a far larger volume of soil. Thus, the depth assigned to a soil gas sample (i.e., the depth of the probe) may not represent the average for the interval integrated in the gas sample taken from it (that is, air may be pulled down from above or up from below). Only analytical errors are given in these data sets.

10.2.2 Confidence Level/Accuracy Judgment
For radon measurements, accuracy is 10% of the measured value, with most of the error caused by uncertainty in the efficiency of the counting cell.

10.2.3 Measurement Error for Parameters
For radon measurements, accuracy is 10% of the measured value, with most of the error caused by uncertainty in the efficiency of the counting cell.

10.2.4 Additional Quality Assessments
None.

10.2.5 Data Verification by Data Center
Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data
None given.

11.2 Known Problems with the Data
None given.

11.3 Usage Guidance
None given.

11.4 Other Relevant Information
None.

12. Application of the Data Set

The data can be used for estimation of soil gas exchange rates from ^{222}Rn data (or testing of soil gas exchange rates derived from models).

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

Calculations of fluxes for radon used linear regression from programs such as Microsoft Excel and Kaleidograph.

14.2 Software Access

None given.

15. Data Access

The TGB-12 ^{222}Rn flux data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
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P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Not applicable.

17.2 Journal Articles and Study Reports

Davidson, E.A. and S.E. Trumbore. 1995. Gas diffusivity and production of CO_2 in deep soils of the eastern Amazon. Tellus. 47B: 550-565.

Mathieu, G.G., P.E. Biscaye, R.A. Lupton, and D.E. Hammond. 1988. System for measurement of ^{222}Rn at low levels in natural waters. Heath Physics 55:989-992.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

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Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Stephens, B.B. and E.T. Sundquist. 1998. Measurements of soil surface gas fluxes using closed chamber techniques, submitted for publication.

Trumbore, S.E. 1995. Use of isotopes and tracers in the study of emission and consumption of trace gases in terrestrial environments. Chapter 9 in: Matson, P and Harriss, R, (eds.). Biogenic Trace Gases: Measuring Emissions from Soil and Water, Blackwell, Oxford, p. 291-326.

Winston, G.C., E.T. Sundquist, B.B. Stephens, and S.E. Trumbore. 1997. Winter CO_2 fluxes in a boreal forest. Journal of Geophysical Research 102(D24):28,795-28,804.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None given.

19. List of Acronyms

```
AEAC    - Albers Equal-Area Conic
AFM     - Airborne Fluxes and Meteorology
AMS     - Accelerator Mass Spectrometry
ASCII   - American Standard Code for Information Interchange
AVHRR   - Advanced Very High Resolution Radiometer
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact-Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
GIS     - Geographic Information System
GSFC    - Goddard Space Flight Center
HTML    - Hyper-Text Markup Language
IRGA    - Infrared Gas Analyzer
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
TDR     - Time Domain Reflectometry
TGB     - Trace Gas Biogeochemistry
TM      - Thematic Mapper
SSA     - Southern Study Area
URL     - Uniform Resource Locator
USGS    - United Stated Geological Survey
YJP     - Young Jack Pine
```

20. Document Information

20.1 Document Revision Date

Written: 14-Nov-1997
Last Updated: 09-Jul-1999

20.2 Document Review Date(s)

BORIS Review: 10-Jul-1998
Science Review:

20.3 Document ID

20.4 Citation

For soils data, the U.S. Geological Survey (USGS) open file reports (see Section 17.2) should be cited. For interpretations, cite submitted Journal of Geophysical Research papers (see Section 17.2). Other citations should refer to the BOREAS Information System (BORIS) data set.

If using data from the BOREAS CD-ROM series, also reference the data as:

Trumbore, S., J. Harden, and E. Sundquist, "Input, Accumulation and Turnover of Carbon in BOREAS NSA Soils (TGB-12)." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 2000	Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS TGB-12 ^{222}Rn Flux Data over the NSA

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
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Forrest G. Hall and Sara K. Conrad, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 246

11. SUPPLEMENTARY NOTES
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12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The BOREAS TGB-12 team made measurements of soil carbon inventories, carbon concentration in soil gases, and rates of soil respiration at several sites to estimate the rates of carbon accumulation and turnover in each of the major vegetation types. Sampling strategies for soils were designed to take advantage of local fire chronosequences, so that the accumulation of carbon in new moss growth could be determined. All the data are used to 1) calculate the inventory of carbon and nitrogen in moss and mineral soil layers at NSA sites, 2) determine the rates of input and turnover (using both accumulation since the last stand-killing fire and radiocarbon data), and 3) link changes in soil respiration rate to shifts in the ^{14}C content of soil CO_2 to determine the average 'age' respired CO_2. These ^{222}Rn flux data were collected from 15-Nov-1993 to 16-Aug-1994 over the NSA sites. The data in this data set are stored in tabular ASCII files.

14. SUBJECT TERMS	15. NUMBER OF PAGES
BOREAS, trace gas biogeochemistry.	13
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL